F.W. BELL

6120 HANGING MOSS ROAD
ORLANDO, FL 32807
PHONE: 305-678-6900
TWX: 810-853-3115
FAX: 305-677-5765

INSTRUCTION MANUAL

UTI[illegible]ASTER
CURR[illegible]NT/POWER PROBE
MODEL UM-7700

F.W. BELL

360689

SPECIFICATIONS

ELECTRICAL PARAMETERS

Unless otherwise stated, all ratings are valid from –15°C to 35°C at 0% to 90% relative humidity (R.H.), and from 35°C to 50°C at 0% to 70% R.H.

RANGE	±1 to 1000 amperes dc, 1 to 1000 amperes ac 0.1 to 330 kW ac (90-660 Vac and 1-500 A ac in kW). Usable from 0.1 to 1500 A dc, 1200 A ac and 700 A ac in kW. (Above 1000 A use for 5 seconds maximum)		
FREQUENCY RANGE	dc to 500 Hz		
VOLTAGE INPUT IMPEDANCE	380 kΩ nominal		
OUTPUT	±1 mV dc/input ampere dc 1 mV ac/ampere ac ±1 mV dc/input kW ac		
OUTPUT ACCURACY*	dc	1 to 700 A :	±1.5% of reading ±2.0 A
		700 to 1000 A :	±2.5% of reading ±2.0 A
	48 to 62 Hz	1 to 500 A :	±1.5% of reading ±1.5 A
		500 to 700 A :	±2.5% of reading
		700 to 1000 A :	±4.5% of reading
		0.10 to 330 kW ac :	±2.5% of reading ±500 W (Power Factor >0.5)
	dc to 100 Hz	1 to 500 A :	±2.0% of reading ±2.0 A
	100 Hz to 200 Hz		±2.8% of reading
	200 Hz to 400 Hz		±4.0% of reading
	400 Hz to 500 Hz		±5.0% of reading
	dc to 100 Hz	500 to 700 A :	±3.0% of reading ±2.0 A
	100 Hz to 200 Hz		±3.8% of reading
	200 Hz to 400 Hz		±5.0% of reading
	400 Hz to 500 Hz		±6.0% of reading
	dc to 100 Hz	700 to 1000 A :	±5.0% of reading ±2.0 A
	100 Hz to 200 Hz		±5.8% of reading
	200 Hz to 400 Hz		±6.8% of reading
	400 Hz to 500 Hz		±8.0% of reading
	400 Hz	0.10 to 330 kW ac :	±3% of reading ±500 W (Power Factor >0.7)

December, 1986 UN-01-166 Litho in USA

INFLUENCES ON ACCURACY	Conductor off-center: <1.5% change with 0.63 inches (16 mm) or larger diameter cable. Adjacent conductor current: <0.015 A/A Non-sinusoidal ac Waveforms: Rated accuracy for crest factor <3.5 (**NOTE:** Waveform may be altered by the attenuation of harmonics) Temperature coefficient is 0.05 x accuracy/°C (–15 to 18°C, 28 to 50°C)
LONG TERM STABILITY	±0.5%/1000 hours (estimated)
VOLTAGE WITHSTAND**	4640 V, 60 Hz between core and probe output for one minute (Test requirement for 660 working volts)
LEAKAGE	0.5 mA maximum with 660 V, 60 Hz between core and probe output for one minute
BATTERY	1 each 9V alkaline battery
BATTERY CONSUMPTION	5 mA nominal (100 hours typical battery life)
BATTERY TEST	Power LED indicates acceptable batteries (probe meets accuracy specifications)
OPERATING TEMPERATURE	–15°C to 50°C
STORAGE TEMPERATURE	–40°C to 60°C

MECHANICAL PARAMETERS

OUTPUT CONNECTION	1.5 meter black cable (SPT-1 or equivalent) terminated with two color-coded banana plug capable of reaching 6 inches apart. Plugs are safety-designed
VOLTAGE INPUT	Safety-designed banana plugs
VOLTAGE CONNECTIONS	Test leads provided
CASE MATERIAL	Black flame retardant ABS (KJB)
WEIGHT	1 lb. 13 oz. (822 grams) nominal

*(Conductor centered, output terminated into 100 kΩ minimum load resistance and 100 pF maximum capacity, ac input is sine wave, 18°C to 28°C.)

**Test done per IEC 348 (conditioned at 40°C, 95% R.H. for 48 hours, tested between 15°C and 35°C, <80% R.H.)

FEATURES

- Measures dc and ac current
- Clamps around conductors up to 2⅜" diameter
- Measures "Real" ac power
- Usable to 1 kA and 330 kW ac
- Measures power in distorted waveforms
- Output useable with oscilloscope, DVM, and Recorder
- Directional measurement capability
- Low-phase angle error
- Clamp-on current input
- Plug-in voltage input
- Easy, safe, one-hand operation
- Low battery drain
- Low battery indicators
- Portable
- Tough, durable ABS plastic housing

APPLICATIONS

- Measure ground currents dc and ac
- Measure power supply ripple
- Measure current distribution in multiple mesh systems
- Measure current balance (two wires) dc or ac
- Measure starting currents without introducing impedance (imparts negligible inductance in the μH range)
- Measure capacitor leakage
- Measure transformer currents
- Measure battery currents (charging and discharging)
- Display current transients to limit of frequency response
- Measure current distribution and perform ripple tests in plating operations
- Read currents in HV conductors through non-magnetic insulation
- Measure motor power for load control
- Measure residential power consumption
- Measure system power draw
- Appliance testing
- Plant maintenance and inspection
- Electric utility testing

SIMPLIFIED OPERATING INSTRUCTIONS

1. Install 9-volt battery in battery compartment.

2. Connect appropriate readout device to the output jacks.

3. Zero the probe by using the zero knob on the top of the probe. Be sure to use proper zeroing techniques. (See page 8, paragraph 3.)

4. CURRENT MEASUREMENTS: Clamp the probe around the conductor you intend to measure. The voltage seen on the indicating device hooked to the output of the UM-7700 probe is calibrated for 1 millivolt per ampere.

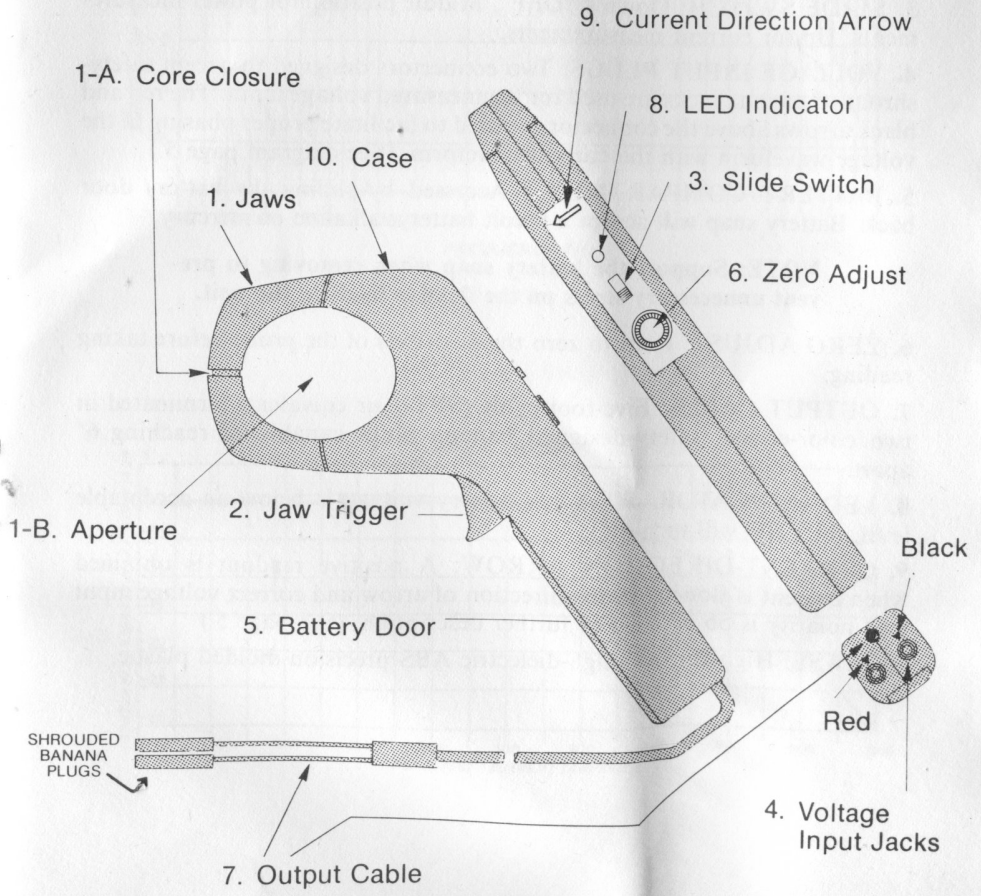
5. POWER MEASUREMENTS: Connect the voltage input leads to the load. Rezero the probe, clamp the probe over the conductor. The output indicating device is now calibrated for 1 millivolt dc per kilowatt of true power.

For complete details and measurement techniques please consult the appropriate section of this manual.

TABLE OF CONTENTS

FUNCTIONAL DESCRIPTION

The Model UM-7700 Utility Master is designed to measure ac and dc current and ac power. In all operating modes, measurement of current is obtained via dual Hall effect devices mounted in the movable jaws. For ac power measurements, the appropriate voltage signal is obtained by connecting the red and black voltage input leads to the load voltage. Under these circumstances, the UM-7700 accomplishes the multiplication of the current, voltage, and phase angle to provide an indication of the real power being delivered to the load. In all measurement modes, an output signal is provided on a pair of shrouded banana jacks designed to interface with a voltmeter, multimeter, oscilloscope or recording instruments.



PHYSICAL DESCRIPTION

1. JAWS: Open to accept conductors up to 2⅜" diameter. Insulated, except at core closure (1-A.).

CAUTION: DO NOT USE ON BARE CONDUCTORS OR AT VOLTAGES ABOVE 660 Vac.

NOTE: Inspect core closure area frequently for foreign material. Avoid snapping the jaws as this can damage the core and/or alter the zero set. Centering of conductors smaller than 2⅜" diameter within the aperture (1-B.) is desirable, but not critical within specified accuracy limits.

2. JAW TRIGGER: Designed for easy, one-hand opening of jaws. Positioned for maximum protection from circuit voltages.

3. SLIDE SWITCH: Down = "OFF". Middle position for power measurements. Up for current measurements.

4. VOLTAGE INPUT PLUGS: Two connectors designed to accept safety-shrouded banana jacks are used for the measured voltage input. The red and black arrows above the connector are used to facilitate proper phasing of the voltage waveform with the current waveform. (See diagram page 5.)

5. BATTERY COMPARTMENT: Accessed by sliding the battery door back. Battery snap will accept a 9-volt battery, alkaline or mercury.

NOTE: Support the battery snap when removing to prevent unnecessary stress on the flexible leads to the unit.

6. ZERO ADJUST: Used to zero the dc offsets of the probe before taking reading.

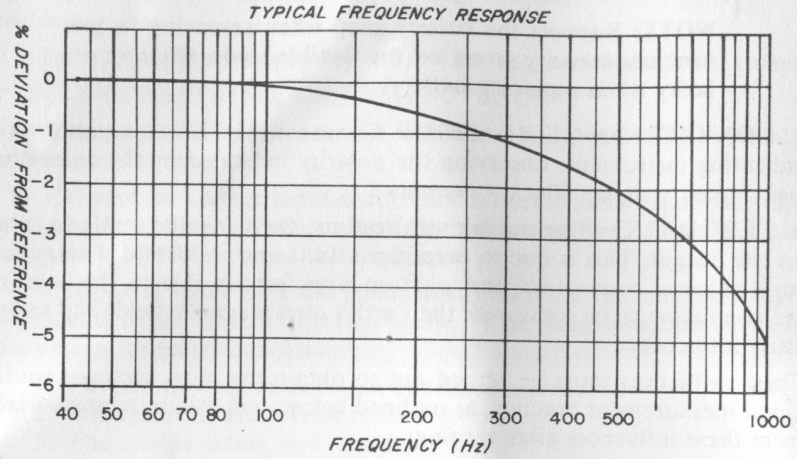
7. OUTPUT CABLE: Five-foot cable (SPT-1 or eqivalent) terminated in two color-coded, safety-designed banana plugs capable of reaching 6" apart.

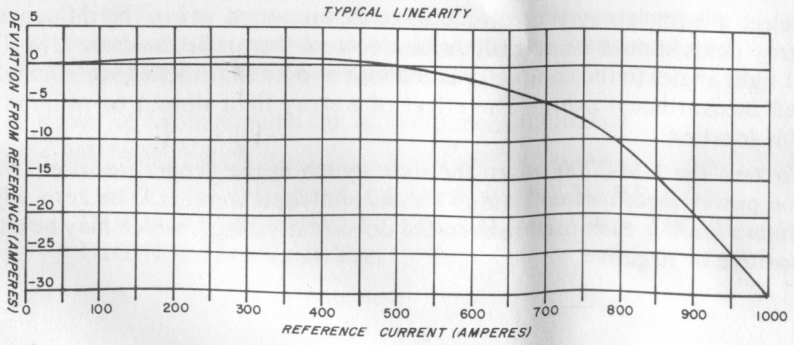
8. LED INDICATOR: When the battery voltage is below an acceptable level, the LED will turn off.

9. CURRENT-DIRECTION ARROW: A positive readout is obtained when current is flowing in the direction of arrow and correct voltage input lead polarity is observed. For further description. (See page 5.)

10. CASE: High-Impact, high-dielectric ABS precision-molded plastic.

PERFORMANCE CURVES FOR THE UM-7700 IN CURRENT MODE





OPERATION PROCEDURE

1. BATTERY INSTALLATION: Put the slide switch to "OFF", slide battery door back, find the battery snap and install a 9-volt battery (Eveready, Alkaline No. 522, NEDA 1640A, or equivalent). Slide battery door to the closed position.

NOTE: Support the battery snap when removing to prevent unnecessary stress on the flexible leads. Observe polarity when replacing battery.

2. CONNECTION OF READOUT: Connect UM-7700 to an appropriate indicating instrument, observing the polarity indicated by the color-coded jacks. (Red = signal; Black = common)

3. ZEROING: Even before taking a reading, there may be small dc voltage on the output. This is due to amplifier offsets and influence of stray fields from adjacent conductors, and/or from large ferrous objects, the field from the conductor to be measured, the Earth's own magnetic field, and temperature influences.

These influences must be zeroed out to obtain the most accurate reading. Good measurement practice, as outlined below, will minimize any variables from these influences after zeroing.

For power measurements, connect the red voltage lead to the positive or hot side of the load, then connect the black voltage input lead to the negative or common side of the load.

CAUTION: DO NOT USE WITH VOLTAGES EXCEEDING 660 Vac.

Select a point along the conductor to be measured where the influence of stray fields should be at a minimum. To zero the probe, hold the UM-7700 at right angles to the conductor and about two- to four-inches out from selected measurement point. The effect of a stray field should be minimal at this location.

To zero the UM-7700, place the slide switch in the proper position...watts for power measurement, amps for current measurement. The zero adjust thumb knob is then used to zero the dc output voltage, which may be either positive or negative.

4. CURRENT (AMPS) MEASUREMENT:

A. Connect the output leads to a voltmeter, multimeter, oscilloscope or recording instrument.

B. Zero the UM-7700 as described below.

C. The voltage seen at the output cable is an accurate analog signal proportional to the ac, dc, or composite (ac-on-dc) current through the conductor.

D. The voltage output sensitivity is 1 mV per ampere of conductor current.

5. POWER (WATTS) MEASUREMENT "ac ONLY"

A. Connect the output leads to a voltmeter, multimeter, oscilloscope or recording instrument.

B. Connect the voltage input connectors to the load and adjust the output for a zero dc reading with the unit off the conductor (See ZEROING), then clamp the UM-7700 around the conductor.

C. Clamp the jaws over the conductor, observing the current polarity, as indicated by the current direction arrow. Three conditions exist which can give a negative meter indication.

1. Current flowing in direction opposite to arrow.
2. Voltage leads are reversed.
3. The load is acting as a source.

D. The output voltage is proportional to the instantaneous product of the load voltage and load current and contains a dc and an ac component. The dc component is proportional to the true power and the ac component is proportional to the apparent power (volt x amperes).

E. The output is calibrated for 1 m Vdc per kilowatt of True Power.

NOTE: For power measurements, the measurement device must be capable of blocking the ac component and measure only the dc component.

For sinewave measurements the ac component multiplied by $\sqrt{2}$ will equal V x A.

CAUTION: DO NOT CLAMP ONTO BARE CONDUCTORS, OR CONDUCTORS HAVING VOLTAGES HIGHER THAN 660 Vac.

MEASUREMENT NOTES

1. There can be a few millivolts of thermal drift during the first 60 to 120 seconds of warm-up. For maximum accuracy, a warm-up of 60 seconds before zeroing will eliminate 90-95% of the drift.

2. Where possible, when taking low-level power measurements, looping a number of turns of the current-carrying conductor around the bottom jaw will multiply the sensitivity of the readings. To obtain the correct power, the reading on the meter must be divided by the total number of turns through the aperture.

3. Keep core closure area clean of foreign materials.

4. Make sure core closes completely around conductors.

5. For maximum accuracy, rezero after every reading. This is especially important during dc measurements. When the power gun is exposed to a relatively high current, it is possible to create a magnetic offset which can be zeroed out.

WHAT IS POWER?

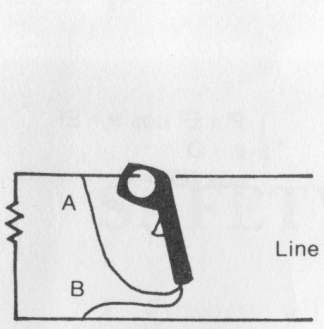
Power is the measure of the rate of energy consumption. To the electrical worker it is the amount of volts x amperes flowing in a circuit as expressed in watts. DC power is the product of the voltage applied to the load multiplied by the total current flowing into the load (P = I x E). With ac voltages and currents, power measurements take on a whole new meaning. In place of the direct I x E product, the voltage and current must be multiplied vectorally. In ac power the product of the voltage times the current is called VA (volt amps) and represents the amount of apparent power consumed by the load. The vectoral product of the voltage and current is called True Power or Real Power, and represents the actual power consumed by the load.

The angular difference between the current and voltage is called θ (Theta) and cosine θ is the power factor. When the current and voltage are in phase, the load is said to be resistive and the power factor is one. When the voltage is out of phase with the current and begins to lead or lag the current, the true power must be multiplied by cosine θ. Therefore, true power for any ac circuit must equal E x I cos θ. The UM-7700, by its design, measures E x I cosine θ and is read in watts.

WHY IS THIS IMPORTANT?

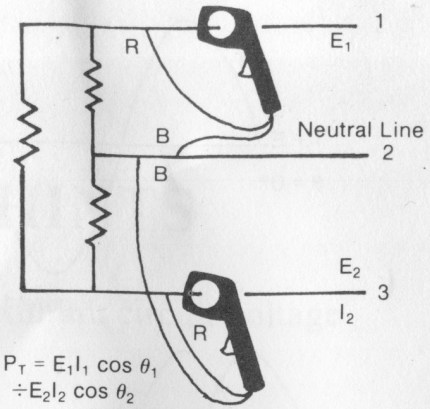
Depending on the power factor (cosine θ), the real power may be much less than the apparent power. The difference in power is called reactive power and does no work. Motors and heating elements that are designed to operate on a limited duty cycle will be required to operate longer and work harder because of the decrease in true power. As the power factor is decreased from unity (1) and applied voltage is held constant, the operating current must increase in order to develop the same power. Motors and other electrical devices that are not designed to handle this increase in current may overheat and burn up. Decreasing the true power applied to a circuit may cause greater decrease in operating efficiency resulting in increased wear on the electrical device.

POWER MEASUREMENT TECHNIQUES



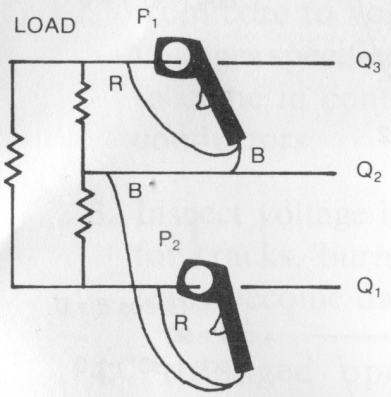
$P_T = EI \cos \theta$

SINGLE-PHASE
Fig. 1



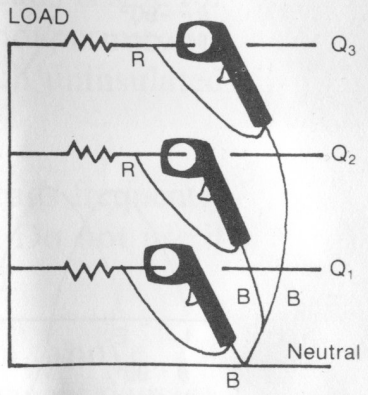
$P_T = E_1I_1 \cos \theta_1 \div E_2I_2 \cos \theta_2$

SINGLE-PHASE 3-WIRE
Fig. 2



$P_T = P_1 + P_2$

THREE-PHASE 3-WIRE DELTA or γ
Fig. 3



$P_T = P_1 + P_2 + P_3$

THREE-PHASE 4-WIRE
Fig. 4

Single-phase power may be measured by connecting the UM-7700 as shown in Fig. 1. Power consumed by the load is read in kilowatts by the UM-7700. The total power consumed by various loads in a conventional residential hookup may be measured by connecting the UM-7700 as shown in Fig. 2. The total power is the power measured on line one, added to the power measured on line three.

For three-phase systems refer to Figures 3 and 4 for detailed power measurement connections. In three-phase 3-wire systems, only two power measurements need to be made to arrive at the total power. However, in three-phase, 4-wire systems, it is necessary to measure the power for all three phases.

I & E RELATIONSHIPS WITH RESPECT TO LOAD

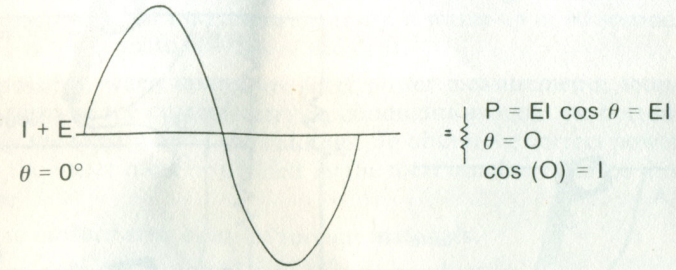


Figure 1

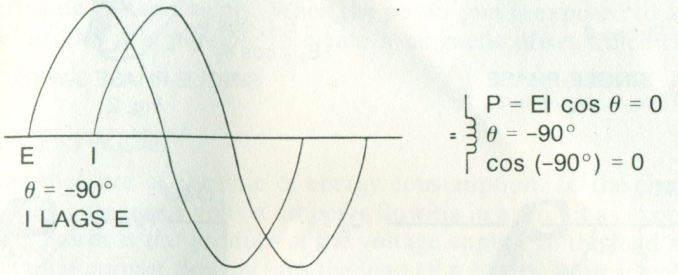


Figure 2

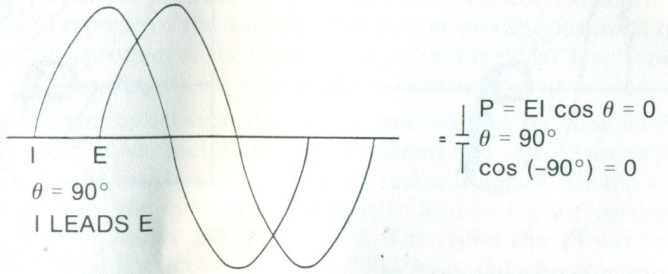
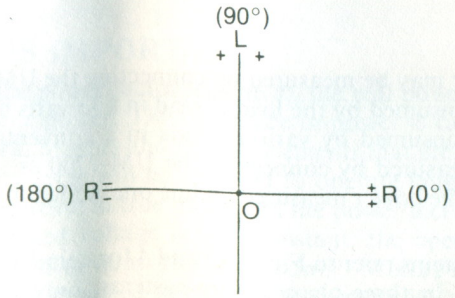


Figure 3



SAFETY HINTS

1. Observe all maximum circuit voltage cautions.
2. The aperture is insulated except at the core closure. Withstand capability from core to voltage leads is safe for voltages specified. Do not permit core to come in contact with uninsulated conductors.
3. Inspect voltage input leads frequently for cracks, burns, etc. Do not use if leads become damaged.
4. Prolonged operation above 250 A•kHz can cause permanent damage, due to heating effects. Do not use probe under conditions where the current frequency product is higher than 250 A•kHz.

WARRANTY

F.W. BELL, INC. warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this warranty is limited to servicing or adjusting free of charge any Utility Master Probes returned to our factory for that purpose. This warranty covers Utility Master Probes which, within 1 year after delivery to the original purchaser, shall be returned with transportation charges prepaid by the original purchaser, and which upon examination shall disclose to our satisfaction to be defective. If it is determined that the defect has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost after submitting an estimate to the purchaser.

F.W. BELL, INC. reserves the right to make changes in design at any time without incurring any obligations to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of F.W. BELL, INC., and F.W. BELL, INC. neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of F.W. BELL, INC. Utility Master Probes.

DAMAGE IN SHIPMENT

The instrument should be examined and tested as soon as it is received. If it does not operate properly, or is damaged in any way, immediately file a claim with the carrier. The claim agent will provide report forms. A copy of the completed form should be forwarded to us. We will then make necessary arrangements for repair or replacement.